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PATENT
Atty. Dkt. No. APPM/3049.X1/CPES/DT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of:
Cohen, et al.

Serial No.: 09/206,027 — Group Art Unit: 1765

Confirmation No.: 4950 — Examiner: Lan Vinh

Filed: December 4, 1998

For: Plasma Preclean With Argon, Helium and Hydrogen Gases

Commissioner for Patents
Washington, D.C. 20231

CERTIFICATE OF MAILING
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I hereby certify that this correspondence is being deposited on December 23, 2002 with the United States Postal Service as First Class Mail in an envelope addressed to: Commissioner for Patents, Washington, D.C. 20231.
12/23/02 Robb D. Edmonds
Date Signature

Dear Sir:

APPEAL BRIEF

Applicants submit this Appeal Brief to the Board of Patent Appeals and Interferences on appeal from the decision of the Examiner of Group Art Unit 1765 dated July 23, 2002, finally rejecting claims 1, 3-8, and 10-40. Please charge the fee of $320.00 for filing this brief to Deposit Account No. 20-0782/APPM/3049.X1/RDE. Three copies of this brief are submitted for use by the Board.

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Real Party in Interest

The present application has been assigned to Applied Materials, Inc., 3050 Bowers Avenue, Santa Clara, California 95054.

Related Appeals and Interferences

Applicant asserts that no other appeals or interferences are known to the Applicant, the Applicant's legal representative, or assignee which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

Status of Claims

Claims 1, 3-8, and 10-40 are pending in the application. Claims 1-17 were originally presented in the application. New claims 18-23 were added in a response to Office Action dated February 17, 2000, mailed on May 17, 2000. Claims 2 and 9 were canceled without prejudice, and new claims 24-30 were added in a response to Office Action dated July 5, 2000, mailed on October 5, 2000. New claims 31-40 were added in a response to Office Action dated November 20, 2001, mailed on March 15, 2002. The rejection of claims 1, 3-8, and 10-40 based on the cited references is appealed. The pending claims are shown in the attached Appendix.

Status of Amendments

The claims in Appendix A include amendments to claims 32 and 37 presented in a response to Final office action mailed by Applicants on May 17, 2002, which were entered by the Examiner.

Summary of Invention

The present invention provides a method for precleaning a patterned dielectric layer to remove native oxides and polymers of hydrocarbons and fluorinated hydrocarbons from small feature sizes. (*See*, specification at page 4, lines 17-20.) The presence of native oxides and other contaminants within a feature having an aspect ratio less than about 4:1 (height to width ratio) typically results in voids by promoting uneven distribution of the depositing metal. (*See*, specification at page 2, lines 23-24 at Figure 4.) The presence of native oxides and other contaminants can also increase contact resistance and reduce electromigration resistance of the features. The acceptable level of contaminants in the features decreases as the features get smaller in width. (*See*, specification at page 3, lines 3-4.)

The native oxides typically form as a result of exposing the substrate surface to oxygen. Oxygen exposure may occur while moving substrates between processing chambers at atmospheric conditions, or when a small amount of oxygen remaining in a vacuum chamber contacts the substrate surface. (*See*, specification at page 2, lines

26-28.) Other contaminants may form as a result of an oxide over-etch, residual photoresist from a stripping process, leftover hydrocarbon or fluorinated hydrocarbon polymers from a previous oxide etch step, or redeposited material from a preclean sputter etch process. Oxide and other contaminants create regions on the substrate which interfere with film formation, by creating regions where film growth is stunted. (*See*, specification at page 2, line 32 through page 3, line 2.)

Conventional precleaning methods use a mixture of argon and a reactive gas, such as hydrogen. A combination of argon and hydrogen provides both a physical etch and a reactive etch to clean features. (*See*, specification at page 4, lines 2-4.) An increase in the argon content in the gas mixture provides a corresponding increase in the etch rate of the preclean process and a corresponding decrease in the etch uniformity of the preclean process. (*See*, specification at page 4, lines 6-8.) This is to be expected since argon is a heavier atom creating a harsher etching effect. The problem is providing an effective oxide and contaminant removal process that does not over-etch or otherwise damage the substrate surface.

The present invention provides a method for processing a substrate in a processing chamber by exposing a patterned substrate surface to a plasma generated from a gas mixture consisting of argon, helium and hydrogen, wherein the gas mixture comprises less than about 75% by volume of argon. Contrary to expectations, the addition of helium to the gas mixture of argon and hydrogen surprisingly increased the etch rate. More surprisingly, the etch amount actually increased as the argon volume percent dropped from about 75% to about 25%, and then the etch amount declined as the argon volume percent was further reduced. (*See*, specification at page 4, lines 17-26, and at Figure 4.) One would have expected the etch rate and the etch amount to decrease as the volume of argon within the plasma decreased.

Issues Presented

1. Whether the Examiner erred in rejecting claims 1, 3, 5, 6, 7, 24-25, and 27-30 under 35 U.S.C. § 103(a) as being unpatentable over *Konecni et al.* (EP 0849 779 A2) or *Tran et al.* (U.S. Patent No. 5,534,445).

2. Whether the Examiner erred in rejecting claims 4, 8, 10-23, 26, and 31-40 under 35 U.S.C. § 103(a) as being unpatentable over *Konecni et al.* (EP 0849 779 A2) or *Tran et al.* (U.S. Patent No. 5,534,445) in view of *Kennard* (U.S. Patent No. 5,935,874).

Grouping of Claims

Pending claims 1, 3-8, and 10-40 do not stand or fall together for all arguments presented by Applicants. Applicants' first argument relates to the first issue for claims 1, 3, 5, 6, 7, 24-25, and 27-30, and claim 1 is representative of the claims. Applicants' second argument relates to the second issue for claims 4, 8, 10-23, 26, and 31-40, and claim 4 is representative of the claims.

ARGUMENT

I. THE EXAMINER ERRED IN REJECTING CLAIMS 1, 3, 5, 6, 7, 24-25, AND 27-30 UNDER 35 U.S.C. § 103(A) AS BEING UNPATENTABLE OVER *KONECNI ET AL.* (EP 0849 779 A2) OR *TRAN ET AL.* (U.S. PATENT NO. 5,534,445) BECAUSE THE REFERENCES DO NOT MOTIVATE OR SUGGEST EXPOSING A PATTERNED SUBSTRATE SURFACE TO A PLASMA GENERATED FROM A GAS MIXTURE CONSISTING OF ARGON, HELIUM AND HYDROGEN, WHEREIN THE GAS MIXTURE COMPRISES LESS THAN ABOUT 75% BY VOLUME OF ARGON.

Claims 1, 3, 5, 6, 7, 24-25, and 27-30 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Konecni et al.* (EP 0849 779 A2). Claims 1, 3, 5, 6, 7, 24-25, 27-30 also stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tran et al.* (U.S. Patent No. 5,534,445). The Examiner states that neither *Konecni et al.* nor *Tran et al.* specifically disclose the percent by volume of argon as recited in the claims, but the Examiner states that "it is well known in the art that etching parameters, such as etchant concentration, temperature, and flow rate, affect both the rate and quality of the plasma etching process." To support this assertion, the Examiner goes so far as to state that *Guinn et al.* (U.S. Patent No. 5,877,032) teaches that a discrete processing parameter (temperature, flow rate, pressure) is varied to change the etch rate. Yet, the claims do not stand rejected over *Guinn et al.*

The Examiner has not established a *prima facie* case of obviousness. *Konecni et al.* teaches a method for coupling conductive material to a contact region of a semiconductor device by bombarding residual material coupled to the contact region with inert ions to increase the reactive surface area of a residual material. *Konecni et al.* also teaches using hydrogen ions to react with the bombarded residual material. (*See*, *Konecni et al.* at col. 6, lines 40-48). *Tran et al.* teaches a process for producing a polysilicon thin film transistor by hydrogenating the thin film transistor and depositing an atomic hydrogen-containing layer on the thin film transistor. The hydrogenation plasma may be a reactant gas of hydrogen or a mixture of hydrogen with nitrogen or with inert gases such as argon and helium. (*See, Tran et al.* at col. 4, lines 43-52.) As admitted by the Examiner, neither *Konecni et al.* nor *Tran et al.* specifically disclose a percent by volume, and certainly not less than 75% of argon.

The Examiner has also provided no basis for concluding that "it is well known in the art that etching parameters, such as etchant concentration, temperature, and flow rate, affect both the rate and quality of the plasma etching process." The Examiner has only provided *Guinn et al.* (U.S. Patent No. 5,877,032) at column 4, lines 1-15, to support this conclusion. First, *Guinn et al.* teaches an etch process using a plasma of fluorocarbons, specifically C_2F_6, not a gas mixture consisting of argon, helium and hydrogen as recited in the claims. (*See*, *Guinn et al.* at col. 2, lines 34-67.) Second, *Guinn et al.* teaches that:

> A discrete processing parameter (e.g. temperature, flow rate, pressure, RF bias, source power, O_2 clean time) is varied to change the etch rate of the photoresist and/or the contact hole. The parameters selected for variation, and the amount by which the parameters are varied, are selected to obtain traces over a range of etch rates. Therefore, only parameters that effect the etch rate when varied are selected for this purpose. (*See*, *Guinn et al.* at col. 4, lines 3-11.)

Contrary to the Examiner's assertion, *Guinn et al.* does not teach varying a concentration or volume of one or more etchants, such as argon and helium, within a mixture of etchant gases. Further, *Guinn et al.* does not state which processing parameter, if any at all, had a direct effect on the etch rate. *Guinn et al.* merely teaches

that parameters that do affect the etch rate, when varied, are selected. Still further, *Guinn et al.* does not teach, show, or suggest that varying a discrete processing parameter would "affect ... the ... quality of the plasma etching process", as asserted by the Examiner. *Guinn et al.* merely teaches changing the etch rate. *Guinn et al.* teaches nothing about the quality of the plasma etching process.

In addition, neither the Examiner nor *Guinn et al.* provides evidence as to which parameter or parameters, if any at all, are result-effective variables. A particular parameter must first be recognized as a result-effective variable, *i.e.* a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. *In re Antoine*, 559 F.2d 618, 195USPQ 6 (CCPA 1977). See also *In re Bosch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980).

A combination of the references, therefore, does not teach, show, or suggest a method for processing a substrate in a processing chamber by exposing a patterned substrate surface to a plasma generated from a gas mixture consisting of argon, helium and hydrogen, wherein the gas mixture comprises less than about 75% by volume of argon, as recited in base claims 1, 24, 31, and 36, as well as those dependent therefrom. Accordingly, withdrawal of the rejection and allowance of the claims is respectfully requested.

Nonetheless, the claimed invention achieves unexpected and surprising results over the closest prior art. The claimed invention provides a method for processing a substrate in a processing chamber that enhances the etching of the substrate by exposing the substrate to a plasma generated from a gas mixture consisting of argon, helium, and hydrogen wherein the helium content of the plasma is increased to increase the etch amount of the patterned substrate surface. (*See,* specification at page 5, lines 24-31 and Figure 4.) Figure 4 of the application shows that the etch rate increased as the volume of argon decreased from 75% by volume to 25% by volume, i.e. the volume of helium was increased. This correlation is contrary to expectations. One would have expected the etch rate to decrease as the volume of argon within the plasma decreased. The claimed invention is contrary to what would have been expected by one having ordinary skill in the art and thus, nonobvious in view of the prior art.

The Examiner, however, states that this evidence of nonobviousness is not commensurate in scope with the claims. Specifically, the Examiner states that Figure 4 shows that "when the Ar volume is reduced to 40% by volume (less than about 75%) although the volume of helium increases, the etch rate decreases." (*See*, Advisory Action dated July 23, 2002.)

Applicants respectfully disagree with the Examiner's interpretation of Figure 4. Figure 4 clearly shows that the etch amount continuously increased as the volume of argon decreased from 75% by volume to 25% by volume, even at 40% by volume. The specification (page 9) shows argon was mixed with a mixture of He and 5% H_2. Decreasing the argon from 75% to 25% therefore necessarily increases the percentage of helium. Accordingly, the showing of unexpected results are commensurate in scope to the claims, and Applicants respectfully request withdrawal of the rejections and allowance of the claims.

II. THE EXAMINER ERRED IN REJECTING CLAIMS 4, 8, 10-23, 26, AND 31-40 UNDER 35 U.S.C. § 103(A) AS BEING UNPATENTABLE OVER *KONECNI ET AL.* (EP 0849 779 A2) OR *TRAN ET AL.* (US 5,534,445) IN VIEW OF *KENNARD* (U.S. PATENT NO. 5,935,874) BECAUSE THE REFERENCES DO NOT MOTIVATE OR SUGGEST INCREASING HELIUM CONTENT TO INCREASE ETCHING OF A PATTERNED SUBSTRATE SURFACE.

Claims 4, 8, 10-23, and 26 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Konecni et al.* (EP 0849 779 A2) in view of *Kennard* (U.S. Patent No. 5,935,874). Claims 4, 8, 10-23, and 26 also stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tran et al.* (U.S. Patent No. 5,534,445) in view of *Kennard* (U.S. Patent No. 5,935,874). Further, claims 31-40 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Konecni et al.* (EP 0849 779 A2) in view of *Kennard* (U.S. Patent No. 5,935,874).

The Examiner states that neither *Konecni et al.* nor *Tran et al.* specifically discloses the step of increasing the helium content/flow rate to increase etching of the patterned substrate surface. The Examiner, however, states that *Kennard* discloses a method for plasma etching a trench comprising the step of "adding/increasing" a flow

volume of helium to a gas mixture chemistry. The Examiner, therefore, asserts that it would have been obvious to modify *Konecni et al.* or *Tran et al.* by increasing the helium content/flow rate to the gas mixture as per *Kennard* "especially because *Kennard* teaches that it is believed that the addition of a relatively high flow volume of helium improves the directionality of the etch by increasing the ion energy, thereby increasing the vertical etch rate into the trench."

A combination of the cited references does not motivate or suggest the claimed invention. *Konecni et al.* and *Tran et al.* have been distinguished above. *Kennard* teaches a method for etching a trench in a monocrystal silicon layer by <u>adding</u> a "relatively" high flow rate of helium to an oxygen/fluorine-based etchant gas, not a gas mixture consisting of argon, helium and hydrogen as recited in the claims. (*See, Kennard* at col. 3, lines 54-61). *Kennard* does not teach, show, or suggest <u>increasing</u> the helium content to increase etching of the patterned substrate surface, as recited in claims 4, 8, 10-23, 26, and 31-35.

As stated by the Examiner, neither *Konecni et al.* nor *Tran et al.* specifically discloses the step of increasing the helium content/flow rate to increase etching of the patterned substrate surface. Moreover, the Examiner has mistakenly taken *Kennard's* teaching of "adding" to be a teaching of "increasing". "Adding" and "increasing" are different concepts that are patentably distinct. Therefore, a combination of the references does not motivate or suggest increasing the helium content to increase etching of the patterned substrate surface, as recited in claims 4, 8, 10-23, 26, and 31-40. Withdrawal of the rejections and allowance of the claims is respectfully requested.

Conclusion

In conclusion, the references cited by the Examiner, neither alone nor in combination, motivate or suggest the claimed invention. The claimed invention also exhibits surprising and unexpected results over the closest prior art. For these reasons, Applicants respectfully submit that the claims are in condition for allowance and respectfully request that the claims be allowed.

Respectfully submitted,

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APPENDIX

1. A method for processing a substrate in a processing chamber, comprising exposing a patterned substrate surface to a plasma generated from a gas mixture consisting of argon, helium and hydrogen, wherein the gas mixture comprises less than about 75% by volume of argon.

3. The method of claim 1, wherein the hydrogen is provided to the processing chamber in a mixture of about 95% by volume of helium and about 5% by volume of hydrogen.

4. The method of claim 1, further comprising increasing the helium content to increase etching of the patterned substrate surface.

5. The method of claim 1, wherein the substrate surface comprises silicon oxide or silicon nitride.

6. The method of claim 1, wherein the plasma is capacitively and inductively powered.

7. The method of claim 1, wherein the gas mixture is introduced into the processing chamber to establish a pressure from about 1 mTorr to about 200 mTorr.

8. A method for processing a substrate in a processing chamber, comprising:

(a) exposing a patterned substrate surface to a plasma generated from a gas mixture consisting of argon, helium and hydrogen; and

(b)increasing the helium content of the plasma to increase etching of the patterned substrate surface, wherein the gas mixture comprises less than about 75% by volume of argon.

10. The method of claim 8, wherein the hydrogen is provided to the processing chamber in a mixture of about 95% by volume of helium and about 5% by volume of hydrogen.

11. The method of claim 8, wherein the substrate surface comprises silicon oxide or silicon nitride.

12. The method of claim 8, wherein the plasma is capacitively and inductively powered.

13. The method of claim 13, wherein the gas mixture is introduced into the processing chamber to establish a pressure from about 1 mTorr to about 200 mTorr.

14. A method for processing a substrate, comprising:

(a) exposing a patterned substrate surface to a plasma generated from a gas mixture comprising argon, helium and hydrogen in a processing chamber, wherein the plasma is capacitively and inductively powered; and

(b) increasing the helium content to increase etching of the patterned substrate surface, wherein the gas mixture comprises less than about 75% by volume of argon.

15. The method of claim 14, wherein the hydrogen is provided to the processing chamber in a mixture of about 95% by volume of helium and about 5% by volume of hydrogen.

16. The method of claim 15, wherein the substrate surface comprises silicon oxide or silicon nitride.

17. The method of claim 14, wherein the gas mixture is introduced into the processing chamber to establish a pressure from about 1 mTorr to about 200 mTorr.

18. The method of claim 1, wherein the gas mixture comprises between about 25% and about 75% by volume of argon.

19. The method of claim 8, wherein the gas mixture comprises between about 25% and about 75% by volume of argon.

20. The method of claim 14, wherein the gas mixture comprises between about 25% and about 75% by volume of argon.

21. The method of claim 1, wherein the plasma is generated by delivering a power level of between about 10 watts and about 500 watts to the processing chamber.

22. The method of claim 8, wherein the plasma is generated by delivering a power level of between about 10 watts and about 500 watts to the processing chamber.

23. The method of claim 14, wherein the plasma is generated by delivering a power level of between about 10 watts and about 500 watts to the processing chamber.

24. A method for processing a substrate in a processing chamber, comprising exposing a patterned substrate surface to a plasma generated from a gas mixture consisting of less than 75% by volume of argon and a mixture of about 95% by volume of helium and about 5% by volume of hydrogen.

25. The method of claim 24, wherein the plasma is capacitively and inductively powered.

26. The method of claim 24, further comprising increasing the helium content to increase etching of the patterned substrate surface.

27. The method of claim 24, wherein the substrate surface comprises silicon oxide or silicon nitride.

28. The method of claim 24, wherein the gas mixture is introduced into the processing chamber to establish a pressure from about 1 mTorr to about 200 mTorr.

29. The method of claim 24, wherein the gas mixture comprises between about 25% and about 75% by volume of argon.

30. The method of claim 24, wherein the plasma is generated by delivering a power level of between about 10 watts and about 500 watts to the processing chamber.

31. A method for processing a substrate in a processing chamber, comprising:

(a) exposing a patterned substrate surface at a pressure between about 5 mTorr and about 20 mTorr to a plasma generated from a gas mixture consisting of argon, helium and hydrogen at a power level between about 300 watts and about 450 watts; and

(b)increasing the helium content of the plasma to increase etching of the patterned substrate surface, wherein the gas mixture comprises less than about 75% by volume of argon.

32. The method of claim 31, wherein the patterned substrate comprises a feature having an aspect ratio greater than about 4 to 1.

33. The method of claim 31, wherein the gas mixture comprises about 50% by volume of argon, about 48% by volume of helium, and about 2% by volume of hydrogen.

34. The method of claim 31, wherein the gas mixture comprises about 25% by volume of argon, about 71% by volume of helium, and about 4% by volume of hydrogen.

35. The method of claim 31, wherein increasing the helium content of the plasma decreases the argon content of the plasma.

36. A method for processing a substrate in a processing chamber, comprising:

exposing a patterned substrate surface at a pressure between about 5 mTorr and about 20 mTorr to a plasma generated at a power level between about 300 watts and about 450 watts from a gas mixture consisting of less than 75% by volume of argon and a mixture of about 95% by volume of helium and about 5% by volume of hydrogen.

37. The method of claim 36, wherein the patterned substrate comprises a feature having an aspect ratio greater than about 4 to 1.

38. The method of claim 36, wherein the gas mixture comprises about 50% by volume of argon, about 48 % by volume of helium, and about 2% by volume of hydrogen.

39. The method of claim 36, wherein the gas mixture comprises about 25% by volume of argon, about 71% by volume of helium, and about 4% by volume of hydrogen.

40. The method of claim 36, further comprising increasing the helium content of the plasma while decreasing the argon content of the plasma.